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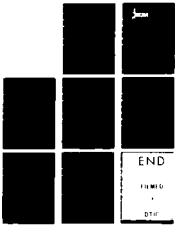

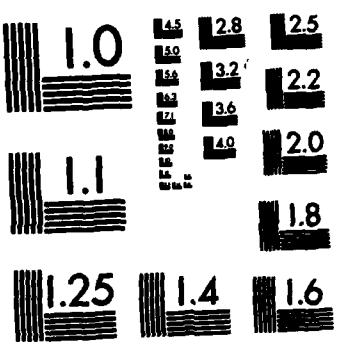

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INTEGRATED NUCLEAR AND CONVENTIONAL THEATER WARFARE SIMULATION (INWARS)

LEVEL III SPECIFICATIONS

VOLUME III: AIR COMBAT MODELING

This document is submitted to Headquarters, Department of the Army, Office os the Deputy Chief of Staff for Operations and Plans, ATTN: Mr. P. E. Louer (DAMO-ZD) Washington, D.C. 20310

FOREWORD

This document is Volume III of five volumes presenting the Level III specifications for the Integrated Nuclear and Conventional Theater Warfare Simulation (INWARS) under development for the U.S. Army by the BDM Corporation. This volume is concerned with the modeling of Air Combat.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I
GENERAL FRAMEWORK FOR AIR OPERATIONS

This chapter presents an overview of the design for simulating air combat operations. A highly aggregated model of the process is necessary to avoid excessive expenditure of computer resources and generating unrealistic data requirements. However, certain features appear critical when considering the impacts of air operations in a theater conflict. These features must be included in some reasonable form.

The basic air missions need to be represented, and also limiting conditions because of potential lack of availability of aircraft due to heavy demand. The scheduling of aircraft, consistent with availability, flight time, engagement time, return and turnaround time appears to be important. The effects of enemy air defense on the mission performance, the effects of target engagement, and reconnaissance must be considered. Perhaps most importantly, the relative flexibility of air, considered as a high-level combat support resource, must be properly represented.

A. AIR MISSION PACKAGES, AIR BATTLES

The central element of the INWARS air operations representation is an Air Mission Package (AMP). Each AMP will be a standarized grouping of various aircraft appropriate to support a particular air mission (Air Defense, Reconnaissance, Interdiction, SAM/Air Base attack, Close Air Support, and Nuclear Withhold). Operating under the control and guidance of an ATAF/TAA air C^2I element, AMPs will be assembled from available type aircraft and then launched on particular missions.

The theater will be divided into Air Battles (ABs) which will be associated with existing NATO ATAF/Army Group commands as well as anticipated command assignments for Warsaw Pact Tactical Air Armies/Fronts. As a result of this configuration, there would be two Air Battles for NATO, one associated with each ATAF, and three Air Battles for Warsaw Pact territory, one associated with each Tactical Air Army/Front. This proposed

configuration is illustrated by Figure I-1. The air battle associated with 2 ATAF and Front 2 are highlighted. These ABs will contain the air elements that would normally include the ground-based air defense entities that might be encountered enroute to the target. These air battles will not be physically located in the models. Rather they will be bins into which AMP will be placed while enroute to their target. The choice of which AB bin an AMP is placed will be a function of the mission and target of the package.

B. AIR MISSION STRUCTURE

The initial step in mission execution will be "flying to the target" during which AMPs may sustain attrition from area air defenses as well as interceptors if there are any in that particular air battle. "Flying to the target" entails the placement of an AMP into a particular air battle.

Air Battle casualties will be assessed for the AMPs depending on the relative forces present during that time in the ABs. Then the AMPs will "exit" the ABs and fly to their respective targets, where both target engagement and point air defense effects will be ascertained. The AMPs will then return to base via the Air Battle for repair, refueling, and rearmament.

C. TYPE MISSIONS

Aircraft will be launched from the air bases to fly one of five types of missions. These include Air Defense, Reconnaissance, Interdiction, SAM/ Air base attack, and Close Air Support. In addition, there will be a sixth mission type, Nuclear Withhold, which is a specific mission not requiring launching, but which reduces the number of available aircraft for other flying missions.

(1) Air Defense (AD). Aircraft performing this mission will either operate within the friendly air battles with the mission of engaging enemy aircraft attempting to penetrate to attack targets

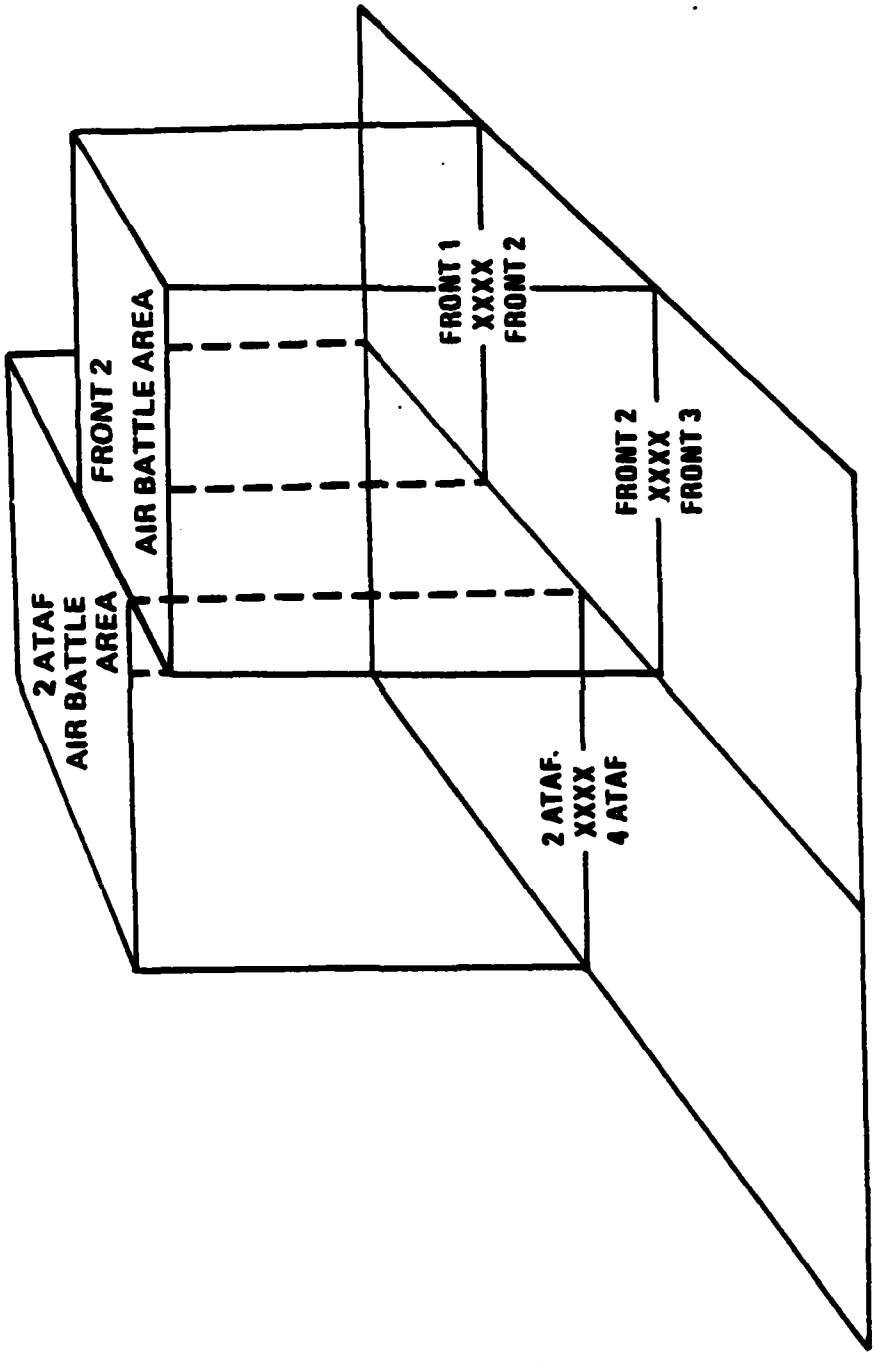


Figure I-1. Concept of Air Battle Areas

located within friendly areas or within enemy air battles with the mission of providing an air defense screen for the friendly penetrators.

(2) Reconnaissance (REC). Aircraft performing this mission can penetrate into enemy ATAF/TAA areas and collect intelligence information or operate in friendly ATAF/TAAs in a standoff mode.

(3) Interdiction (INT). Aircraft performing this mission will penetrate into enemy territory and attack all type targets except enemy air bases and SAM systems.

(4) SAM Attack/Air Base. This is an offensive counterair mission which has the aim of destroying aircraft located on the enemy air bases, degrading enemy air base facilities, and destroying or neutralizing surface-to-air missile (SAM) sites.

(5) Close Air Support (CAS). This mission includes all attacks against enemy ground forces deployed in a forward division.

(6) Nuclear Withhold (QRA). Aircraft assigned this mission will be withheld from combat and prepared to execute nuclear strikes.

D. AIR OPERATIONS: C^2I/FUNCTIONS

1. Ground Headquarters Air Functions

Associated with each ground headquarters level there is in reality, a separate air headquarters or air liaison element. In INWARS, the ground C^2I element structure will include an implicit air function that will perform the air planning and requesting associated with the various headquarters. The decision structure of the simulation requires that the decisionmaking portion of the air combat function be explicitly part of the C^2I structure. Hence, one may consider the air planning as colocated with the appropriate associated C^2I element.

2. Allied Tactical Air Force and Tactical Air Army (ATAF/TAA)

One air headquarters (The ATAF/TAA) will be included in the CIC to perform the implementation of the decisions/goals of the C^2I elements,

and to implicitly include those air functions not explicitly represented in the model.

This air headquarters models the implementation function of several echelons of command as a single entity. This allows a compact representation of the operations. The ATAF/TAA structure is depicted below in Figure I-2.

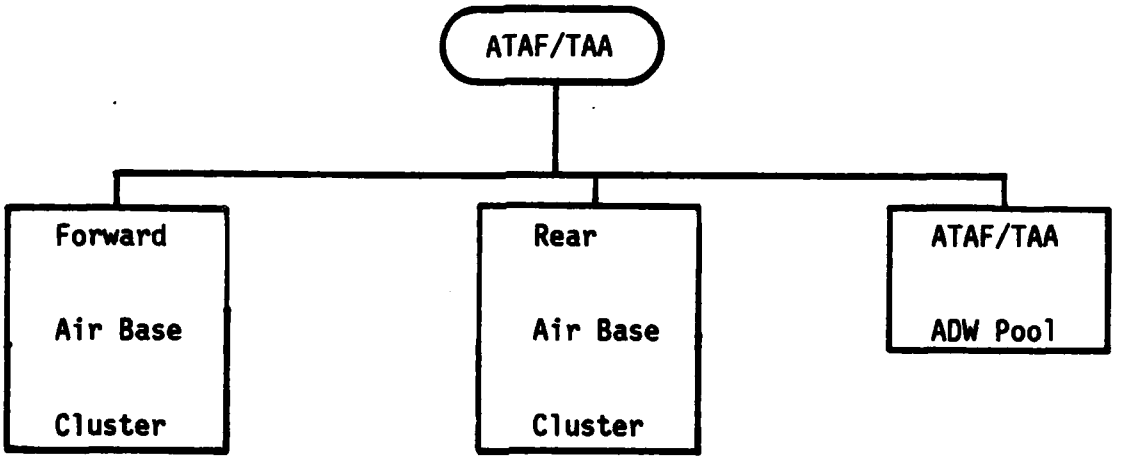


Figure I-2. ATAF/TAA Organization

The Tactical Air Army (TAA) represents the Warsaw Pact equivalent of the ATAF with one exception, i.e., its level in the command chain. In contrast to the NATO organization, the TAA will be subordinate to the Front headquarters as opposed to the theater headquarters.

CHAPTER II
AIR COMBAT ENTITIES AND THEIR REPRESENTATIONS

In INWARS, three entities are defined representing the air combat function. One is the Air Base Cluster (ABC), the second the previously discussed Air Mission Package (AMP), and the third an Air Defense Weapons Pool (ADWP).

A. AIR BASE CLUSTER

Air Base Clusters will represent the air bases associated with a particular ATAF/TAA. Air bases will be located in a level 6 hex with a diameter of 9.43 Km. In each ATAF/TAA INWARS will locate two representative air bases. These air bases will represent a number of actual air bases associated with the particular ATAF/TAA and will be called Air Base Clusters, (ABCs). One air base cluster represents the forward air bases which may be subject to attack by a number of opposing weapon systems. The second air base cluster represents the rear air bases which might be in England and therefore attackable by fewer opposing systems. Forward and rear air bases are included so that some air bases can be represented as being immune to attack by enemy air or missiles. This "immunity" to air attack could be used to portray rules of engagement and/or range limitations of the attacking aircraft. These bases will be designated as rear air bases. Bases within range of enemy air and missiles (and thus subject to attack) are designated as forward air bases. Attacks against ABCs will reduce the capability of the Air Base Clusters and also cause destruction of aircraft on the ground; this will reduce the overall effectiveness of the air combat operations by the associated ATAF/TAA.

B. AIR MISSION PACKAGES (AMP)

An Air Mission Package will be a grouping of specific aircraft types together with representative munition loads or other mission-related equipment needed to execute an attack mission or to provide a given level of

air defense or reconnaissance capability. An aircraft type is a grouping of specific aircraft (F-4D, TORNADO, MIG-23, SU-19) that have similar performance characteristics. As currently envisioned, there will be five aircraft types available for assignment to air mission packages.

Type	Description
1	Air Defense Interceptors only (ADI)
2	Reconnaissance (REC)
3	Conventional-only, multi-mission (CMM)
4	Nuclear/Conventional, multi-mission (NMM)
5	Close Air Support only (CAS)

Quantities of aircraft types will be assigned to specific Air Base Clusters as part of the user input. The composition guidelines for assembling Air Mission Packages will, also, be user determined and be part of the input data. The number of specific type aircraft in a package will be based on the mission and the target size. The capability of an aircraft type to perform a particular type mission would be part of the user input in the form of a matrix of aircraft type and mission role as shown in Figure II-1. This figure is meant to be illustrative only.

	Missions						
Aircraft	AD	REC	INT	ABS	CAS	QRA	Type
ADI	X						
RCE		X					
CMM	X		X	X	X		
NMM	X		X	X	X	X	
CAS					X		

Figure II-1. Example of Mission Aircraft Matrix

Guidelines for the numbers and types of aircraft to be used in composing the various packages will be input to the model by the user. With these guidelines, the ABC would assemble the available aircraft into type AMPs required to support the mission requests. Single purpose aircraft will be used first. Only when there are no single purpose aircraft with multi-mission aircraft be utilized. Thus, close air support aircraft such as A-10's will be utilized whenever available to fill CAS requests. As operational and environmental conditions allow, the Air Mission Packages would begin to be launched from the ABCs. Upon launch, each AMP would be scheduled to enter one of the air battles according to its mission and target location.

C. ATAF/TAA AIR DEFENSE WEAPON POOL (ADWP)

The ADWP will be an aggregation of all Air Defense Weapon Pools organic to C^2I elements subordinate to a particular Army Group or Front. It is this pool that provides the area air defense weapons in the associated Air Battle for that ATAF/TAA.

These area air defense weapons will be considered as contributing to the forces participating in the ABs. They will not be assessed explicitly

as point air defense weapons, unless their location is the target of a specific AMP.

CHAPTER III
AIR OPERATIONS

This chapter presents the operational aspects of the theater air role. Emphasis is placed on what functions are accomplished, and how they are modeled. Section A presents an overview of the aircraft allocation and planning function, and the interaction with the mission implementation phase. Then, the operations of each entity (the ABC's and AMPs) are detailed, concluding with a discussion of mission-air battle-target interactions.

A. OVERVIEW

One of the critical needs in modeling air operations is to obtain a reasonable representation of the mission allocation function. In reality, both preplanned missions, either requested by ground commanders, or layed on by theater operations, and immediate missions must be considered. A proportion of the air resources might be reserved for later missions to allow response to contingencies.

Explicit play of the air planning function from theater downward would require an inordinate investment of INWARS resources. Yet, some reasonable representation is necessary to provide responsive AMPs, scheduled and launched within reasonable time limits, and performing missions that are appropriate.

The methodology for air operations results from partitioning the planning and assignment function from the execution/implementation function. The planning function will occur on a cyclic basis, with a high enough resolution to permit appropriately responsive adjustment to changes in mission demand, and casualties. For example, the AMP allocation process (forming the AMPs) might occur every 2-6 hours (the precise selection of this interval is data and user dependent). Each cycle, the ATAF/TAA C^2I element processes mission goals and mission requests (both from the C^2I units) and executes the allocation of aircraft by assigning AMPs, based

on the situation, the priorities, and the mission requests remaining from the prior cycle. The cycle will reoccur often enough to be responsive to changes in the situation in a realistic fashion.

Once the AMPs have been formed, the operational process of launching, mission implementation etc. is no longer keyed to the decision cycle, but rather to the physical processes of waiting in line for launching, launch, flight-to-target (through the specified ABs) and return to home ABC (perhaps through the AB again).

The time necessary for flight, target engagement, return, repair, refuel, and rearm are all based on the relevant data (e.g. kilometers flown, mission, turnaround time). When AMPs return from a mission, they are decomposed into individual aircraft, which, after a delay representing relevant servicing, are placed in a waiting line ready for composition into a new AMP.

Consideration of the process in two portions, the first a cyclic decision subprocess, and the second the flight, target engagement subprocess allows adequate consideration of the allocation decision in an aggregated fashion, while maintaining the capability of considering the effects of the specific AMPs on assigned targets.

The sequence of actions associated with the air operations begins, as mentioned above, with the composition of an Air Mission Package and its subsequent launch into an air battle. In INWARS, these actions are represented by the following:

(1) Form Air Mission Package (AMP)
(2) Launch AMP
(3) Fly to the Target
(4) Execute Mission
(5) Fly Home
(6) Decompose AMP
(7) TurnAround Aircraft i.e. Simulate Rearm, Refuel, Repair

(8) Place aircraft in Ready Bins

(9) Repeat the sequence

Actions one, two, six, seven and eight are functions of the ABCs, while actions three, four and five are functions of the AMPs.

This sequence of actions will be discussed below under the relevant entities.

B. AIR BASE OPERATIONS

1. Overview

Air bases have the capability to do the following:

(1) Compose air mission packages (AMPs);

(2) Launch aircraft in an AMP at a certain rate consistent with their current runway capability:

(3) Recover and decompose returning AMPs into the various type aircraft;

(4) Process the various type aircraft through queues which would reflect the air bases' capability to rearm, refuel and repair aircraft. This processing will be called "turning around" aircraft; and,

(5) Perform auxillary functions discussed below in subsection 4.

2. Composition and Launch of AMPs

Air mission Packages will be launched by each Air Base Cluster (ABC) based on the guidance it has received from its ATAF/TAA C^2I element. This guidance will be in the form of a utlization schedule containing sortie goals for each of the five air missions that can be flown. These sortie goals will be expressed in the form of "Maximum Sorties per operating period" for each air mission type. For example, the goals might be given as shown in Figure III-1.

The function of the goals given to each ABC is to regulate the strategy that would be followed for the air campaign during that time interval. These goals, established by the Theater and ATAF/TAA operations development activity, include general considerations of the expected needs

to support air and ground operations (see Volume V, Chapter VI for elaboration). The ABCs will accomplish linkup with specific targets or mission objectives by maintaining request queues for each mission type (some mission types may have subgoals (e.g. CAS subgoals for each corps area)) and servicing/launching AMPS on a first come, first served basis for each request as long as the following conditions are fulfilled:

(1) The maximum sortie guidance has not been exceeded;

(2) Air resources required to compose the air mission package are available; and,

(3) Environmental conditions permit launching.

As Amps are composed and launched, the sortie goals in the Utilization Schedule would be correspondingly reduced to reflect partial fulfillment.

In the event that an air air mission request cannot be filled immediately, the request will be placed in a waiting queue. There will be a request queue for the five types of each air missions that can be flown. These backlogged requests will be processed when the conditions placing them in the waiting queues change (e.g., aircraft required for the mission package become available or when the sortie goals guidance changes). The backlogged requests will be processed by sequencing through the waiting queues for each air mission, filling a certain number of requests in each air mission waiting queue. The exact number of requests to be filled for each air mission type on each sequence is a function of the sortie goal for that air mission type and the smallest air mission goal. The process will continue to sequence through the queue until the requests are filled, the goals are met or the resources are unavailable. Figure III-2 illustrates this process.

Processing Sequence for Backlogged Requests

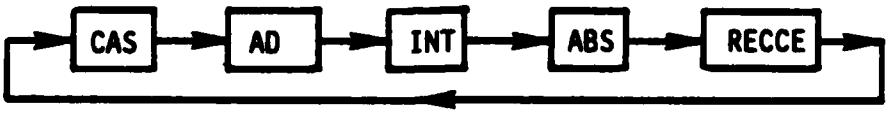


Figure III-2. Example of How Backlogged Requests Are Processed

MISSION/PERIOD	#	1	2	...	N
	START	0600	0800	...	0400
	END	0759	0959	...	0559
COUNTER AIR				...	
AIR DEFENSE					
SAM/AB ATTACK					
ASSOC RECCE					
COMBAT AIR SPT, CORPS/ARMY 1				...	
CLOSE AIR SPT					
ASSOC REC					
⋮		⋮	⋮		⋮
COMBAT AIR SPT CORPS/ARMY N				...	
CLOSE AIR SPT					
ASSOC REC					
INTERDICTION				...	
INTERDICTION					
ASSOC REC					

Figure III-1. ATAF/TAA Utilization Schedule

Air Mission Waiting Queues

	CAS	AD	INT	ABS	RECCE
Example of Goals	100	200	300	50	25
Number of Requests per Sequence	100/25=4	8	12	2	1 Processes

Figure III-2 (continued). Example of How Backlogged Requests Are Processed

It depicts the processing sequence with the calculated number of requests that would be filled for each air mission in this example on one sequence. Thus, 4 CAS, 8 AD, 12 INT, 2ABS, and 1 REC AMP would be processed on one sequence. This sequencing is somewhat artificial, but required in order to preclude filling all the requests for one air mission thereby running out of resources to fill any request for the other air missions.

Once AMPs are composed, they are launched after a delay time representing the launch capability of the ABC. Launch is represented by scheduling the arrival of the AMP into the assigned AB and at the target. The launch capability of an ABC may be degraded by enemy air or missile attack.

3. Recovery and Turnaround of AMPs

As AMPs complete their missions they return to the ABC where they are decomposed and placed into hold areas by type aircraft. These hold areas represent rearm, refuel, and repair areas. Each aircraft will have an associated turnaround rate, which will represent the rate at which they can be rearmed, refueled, repaired and readied to be launched on a new mission. Each ABC will have an assigned capacity to turn aircraft around expressed in the form of a turnaround rate by aircraft type. This capacity may be degraded by attack on the ABC by enemy air or missile.

4. Auxillary Functions

In addition to the primary functions directly involved with the launching, receiving, and processing of air mission packages, air bases have certain other capabilities. They can communicate, they can defend themselves, and they can receive certain items. Specifically, they can do the following:

(1) Receive "composition and launch guidance" from the ATAF/TAA C^2I element,

(2) Report their status to the appropriate ATAF/TAA C^2I element,

(3) Report to the ATAF/TAA C^2I element the occurrence of specific contingency options such as the use of nuclear and chemical weapons on its air bases by the enemy,

(4) Perceive enemy attacks against itself. ABCs will be capable of perceiving enemy air and missile attacks on itself,

(5) Defend itself against enemy air attacks through its implicit "point air defense" capability,

(6) Receive additional aircraft from outside the model i.e., CONUS (this will be a user input, or at a user specified rate)

(7) Recover from attacks by opposing weapon systems. This includes recovering its "turn around" capability as well as recovering its "launch capability."

C. AMP OPERATIONS

1. Overview

After composition, the AMP flies to the target passing though the AB to which it is directed. After suffering (and inflicting) attrition, the AMP proceeds to the target or assigned area for mission execution.

In Mission Execution, aircraft will actually attack their targets. In so doing they will be subjected to attrition by the implicit enemy point air defense associated with the target. Air Defense AMP as well as reconnaissance AMP will be treated differently in executing their missions since they do not attack ground targets.

After execution of its mission, an AMP will fly home through the air battle. In so doing he again will be subjected to attack by area air defenses and enemy interceptors. The attack against returning AMPs will implicitly reflect the reduced priority that these AMPs warrant now that they have executed their missions. High priority will always be placed on incoming AMPs which have not executed their missions.

Upon arrival at its home Air Base Cluster, the AMP will be decomposed into the surviving aircraft, i.e. the AMP will no longer exist. The individual aircraft will be placed in queues by type aircraft. These queues will simulate the unavailability of the aircraft as it rearms, refuels, and gets repaired. After processing through this queue, the aircraft enter ready bins from which the ABC can form new air mission packages and initiate the process again.

2. Air Battle Phase

Air Mission Packages "flying to their target" as well as "returning home" will participate in the air battle. As such, the Air Battles will involve a number of entities: friendly Air Defense Interceptor (ADI) Air Mission Packages, enemy Air Mission Packages, and the Air Defense Weapon Pool (ADWP) of the associated ATAF/TAA. As friendly air defense interceptor packages and enemy mission packages arrive in particular air battle areas, they will be aggregated by type aircraft by side. Effects of air-to-air combat and air defense attrition will be assessed on a periodic basis. The length of the period will be consistent with the average time spent in air AB area. This period will differ from the planning cycle period. At the end of each assessment period, the attrition effects will be distributed among those Air Mission Packages still in the air battle. New AMP arrivals will be included for the next period and AMPs scheduled to exit the air battle will be permitted to continue their mission. Penetrating Air Mission Packages will remain in the air battle area for a specific length of time commensurate with the type mission they are performing and the depth of their target (as judged by the echelon of the target). Air defense interceptors will be scheduled to remain in the air battle to which they are assigned until they have expended their ordnance

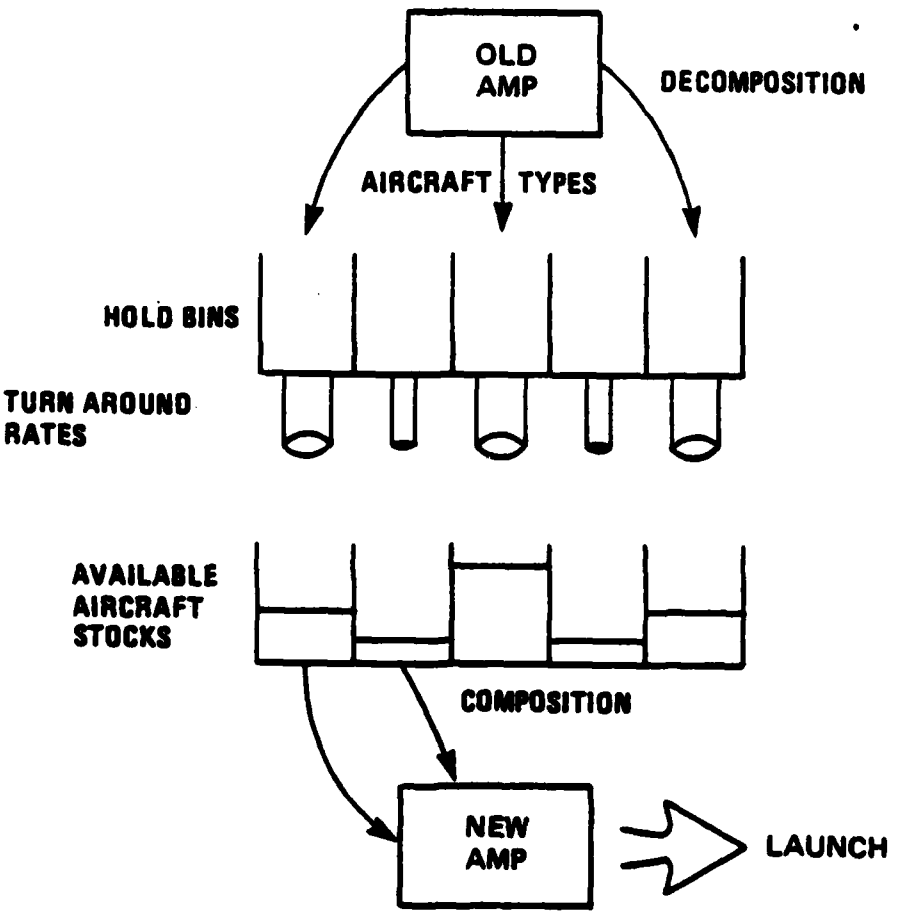


Figure III-3. Aircraft Turn Around Process

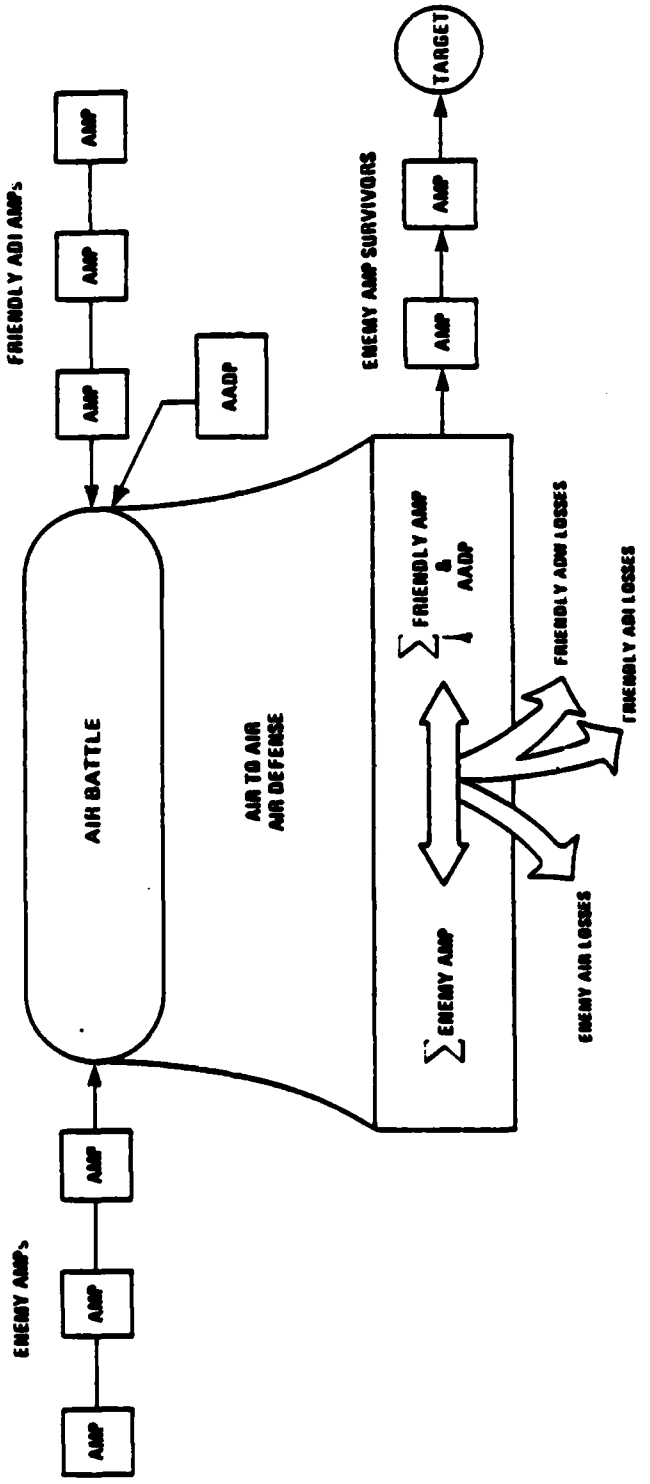


Figure III-4. Air Battle Illustration

particular force elements are specified as targets, the effects will be scored against that element only if they are present in the target hex.

d. SAM/Air Base Attack

Upon exiting the air battle, AMPs assigned an SAM/Air Base attack mission will attack specific Air Base Clusters. The impact of these missions will be reflected in reductions in the rate at which particular aircraft types can be rearmed and refueled as well as in a reduction of the ABC's allowable launch rate. In addition, appropriate attrition of aircraft parked at the ABC and of air defense weapons in the ADWP will be assessed.

e. Close Air Support

Close Air support mission packages will normally spend only a short period of time in the Air Battle since they may only penetrate a few kilometers. However, they will be subjected to engagement by the point air defense associated with the Division sector. Close air support mission packages will be assigned to a particular Corps. The Corps C^2I element will then allocate the AMPs among its subordinate ground elements according to the combat situation at the time the aircraft become available for commitment.

D. AMP-AB-TARGET INTERACTIONS

The AMPs, after allocation by the ATAF/TAA and launch from the ABCs, enter the air battle, depending on their mission assignment. After attrition assessment, they proceed to the target, interact with the target, and return to the ABCs. This section presents a framework for approaching the assessment of these interactions.

1. AMP-AB Interactions

An AMP will enter the air battle at a time scheduled by the ABC, and at the beginning of an AB assessement cycle. This cycle of short duration (e.g., 30 minutes) will be the basic time unit of AB engagement. The AMP resources will be added to the respective resources list for the AB, indicating the total forces present, and then attrition will be assessed

against all AMPs present in that AB. At the conclusion of the AB cycle, the AMP will leave the AB, proportionately degraded in capability depending on the attrition assessment.

The number of AB cycles that an AMP participates in will be a function of the AMP's defined mission. For instance, an AD AMP might stay in for two, three, or four cycles, depending on flight times and munition expenditure rates. A CAS AMP might be in one cycle, then provide support, then return through the AB cycle. The length of the cycle, and the number of cycles participated in by an AMP type is dependent on available data and user requirements.

The attrition assessment is also dependent on data. Basic INWARS will use a variation of the Lanchester Square Law, developed in a manner analogous to that used in the ground combat attrition process (see Volume II, Chapter VI, Section D). Appropriate attention will paid to the availability and suitability of supporting data, and, as the development proceeds, the potential impacts of other techniques.

2. AMP-TARGET Interactions

The need for an aggregated consideration of AMP-target interactions has led to the specification of three major categories for the description of effects. First, the respective attrition effects will be calculated. In Basic INWARS, this will be done utilizing a square law, based on the relative relevant firepower of the AMP and the target.

Next, the target functional degradation will be assessed, with effects varying among different target classes. Finally, any information gained by the AMP as a result of the interaction will in an aggregated fashion be communicated back to the ATAF/TAA, upon return of the AMP.

Figure III-5 presents a list of targets that are considered in INWARS. These targets will be evaluated in terms of expected degradations, information gained and attrition effects (for both attacker and defender) for appropriate AMPs. Figure III-6 presents a pictorial representation of the aggregated information which will be utilized to assess the effects of each AMP.

1. C^2I Elements (Theater HQ, AG/Front HQ, ATAF/TAA HQ, Corps/Army HQ, Division, HQ)

2. Maneuver Elements (Brigade/Regiments)
   - Forward (Committed)
   - Rear (Reserve and Reinforcing)

3. Artillery Units

4. Missile Launchers (as a fraction of missile pools by type and level of command)

5. Forward Air Bases (as a fraction of forward air base clusters by ATAF/TAA)

6. Ground Air Defense Weapons (as a fraction of ground air defense weapons pools by air battle area)

7. Special Weapons Storage Sites/Points

8. Combat Service Support Elements (as a fraction of Combat Service Support Complexes)

Figure III-5. INWARS Target Classes

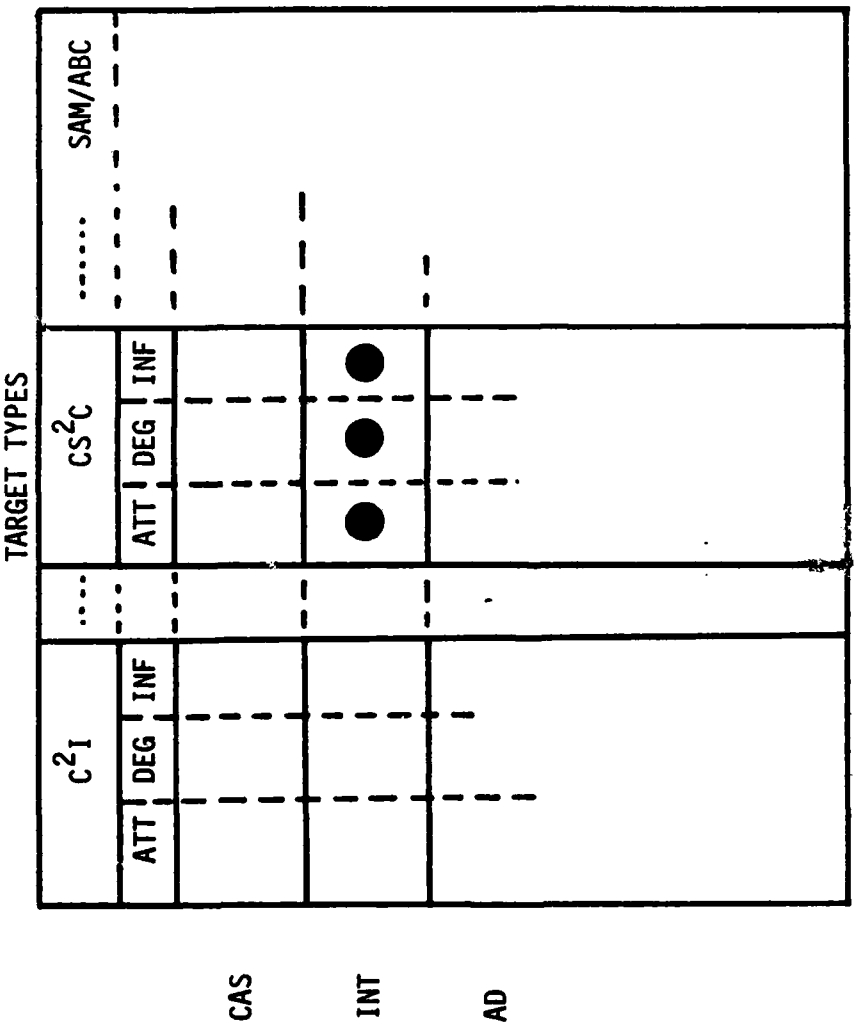
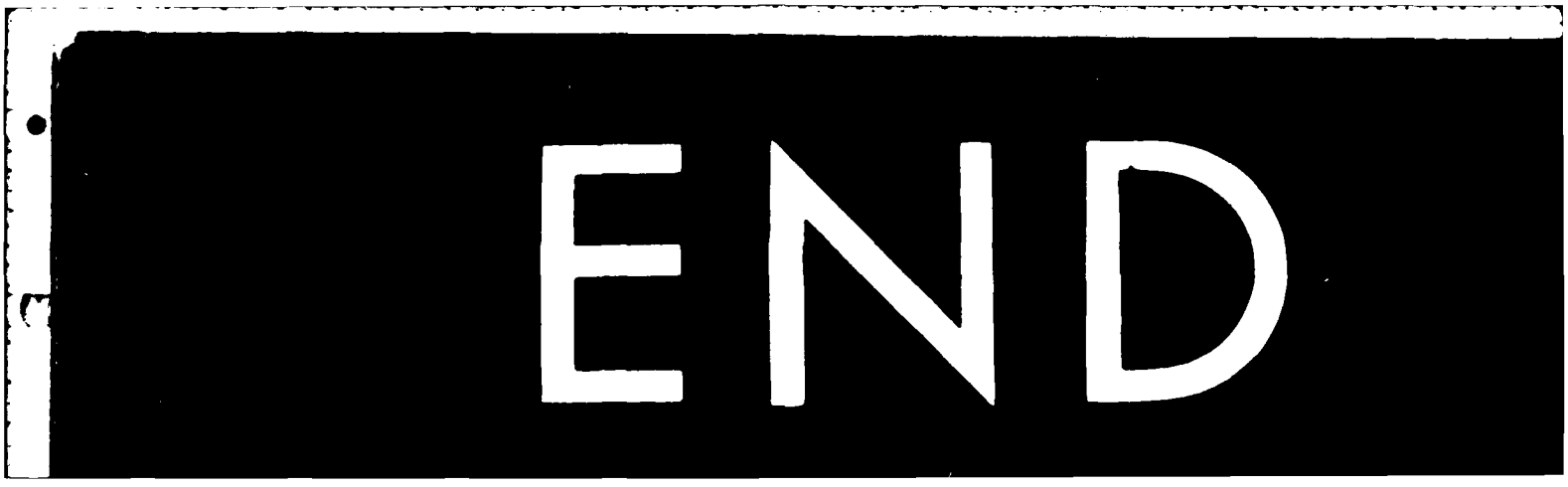


Figure III-6. Mission-Target Interactions Array

For example, an interdiction mission might attack a CS^2C, with attrition resulting from the point air defenses, resources stored at the CS^2C proportionately destroyed, and repair and treatment rates degraded, along with issue capacity. Finally, a "mission-successful" report might be communicated to the ATAF/TAA after the AMP returned to its home ABC.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